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Evaluation of techno-economic feasibility biomass-to-energy by using ASPEN Plus®: A case study of Thailand

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Abstract

The objective of this work is to develop a case-based design process model coupled with technical and economical evaluation around the Biomass Integrated Gasification via Fischer-Tropsch synthesis (BIG-FTs) system in Thailand. Two design scenarios were compared using 10 tons per day of woody residues. The first existing scenario, residues were fed for producing 216 kW of electricity (BIG-GT) in which it can be successfully selling to the Provincial Electricity Authority (PEA). The second scenario relies on the production of merchant liquid transportation fuels 490 Lit/day and surplus electricity 11 kW. Regarding to process descriptions, a conceptual design of BIG-FTs system was developed by using process simulator; ASPEN Plus. Calculation of mass and energy balance, equipment sizing and cost estimation in seven major unit operations were performed. The outputs from the simulation were linked to an economic analysis spreadsheet to estimate the return on investment (ROI), price value (PV), payback period (PB) and to do further sensitivity analysis at the different prices of feedstock. The results of the BIG-FTs system can provide useful information for investors, engineers and researchers as an alternative route of biomass utilization.

Keywords: Biomass Integrated Gasification via Fischer-Tropsch synthesis (BIG-FTs); Biomass Integrated Gasification via gas turbine (BIG-GT); Biomass-to-energy; Process simulation

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1. Introduction

For Thailand, transportation fuels and electricity are the major grass roots to achieve sustainable growth and economic in various sectors such as agriculture, industrial and transportation. From 2000 to 2012, the statistical data indicated that net oil consumption has increased from 749,629 barrels per day to 925,432 barrels per day [1]. At average oil prices of approximately 100 USD per barrel in the year 2008 [2], net oil imports of 813,457 barrels per day would cost about 27.9 billion USD per year. At current prices, this equates to nearly 11% of the 2012 Thai GDP of 15.3 trillion THB or 500 billion USD. Realizing their overreliance on consumed fuels, Thai government has considerably instituted to issue a renewable energy policy focusing on biofuel production in recent years and prioritized biofuel development as a matter of national interest. By timeframes of 15-year (2008–2022), alternative energy goals have been set to reduce oil imports, these targets include biodiesel, bioethanol and other fuel as synthetic fuel from agricultural crops.

Because of more experience with productivity of palm oil and sugar molasses, biodiesel and bioethanol productions were considered as the first generation renewable liquid fuels. In particular, biodiesel productions have already expanded to small communities in rural areas apart from industrial scale production, and 19 existing ethanol plants (2011) have been operated in the middle and northeast parts of Thailand. Meanwhile, agricultural crops were mainly taken for heat and power generation scenario. The numbers of 54 biomass gasification plants were used for electric generation of SPPs (Small Power Producers) and VSPPs (Very Small Power Producers) to sell with the Provincial Electricity Authority (PEA), in order to make these regions independent from grid supply [3]. For alternative thermochemical conversion process solution via gasification, biomass can be gasified to produce synthetic gas or “syngas”, mainly made of carbon monoxide (CO), hydrogen (H_2) and lower content of methane (CH_4) and able to provide a wide range of products. After cleaning and conditioning, the syngas can be used either to synthesize fuels through the Fischer-Tropsch (FT) process, this alternative route may be called that “Biomass Integrated Gasification via FT synthesis (BIG-FTs)”, or associated to gas turbine (BIG-GT) for power generation with electrical capacity from tens of kWe up to a few MWe by different pathways. Although FT synthesis technology has been available for many years as an alternative route for production of transportation fuels [4-7], it has not been strongly supported until the reoccurrence of the petroleum crisis and recent global climate is concerned.

After visiting some gasification plants, lack of support in operation of research activities is a major hurdle for an insertion of FT technology in Thailand. R&D organization and demonstration projects for FT technologies have been financed and commissioned by some government agency, private research institutes and universities. However, there is a lack of integration for these activities towards the existing gas producer such as biomass gasification plants. It would be very useful this time to link up the R&D data to build the pilot units in order to provide valuable design data for establishment of commercial plants. With open-wide opportunity for a great renewable energy policy by Thai government, the techno-economic feasibility assessment of BIG-FTs process provides information which can be exploited by investors or outsiders to acknowledge this alternative route and gain experience in this area. The assessment has been situated to argue with the uncertainty factors because of new technology transfer, improved methods and economies of scale.

The goal of this paper is to provide results of a feasibility study of the production of biomass-to-energy; a case study in Thailand. In details, combination of biomass gasification and FT synthesis was considered, in which both production processes of electricity and liquid biofuels were assessed. The advantages for each process scenario were compared. In this sense, the authors also aim to develop a systematic approach to flowsheet design for BIG-FTs process. Demonstration plant scale based on biomass gasification utilizing 10 ton/day of woody residues from pulp and paper mill industry was considered. The viewpoints of design and performance evaluation of these processes were developed by integrating the technical and economic information through process simulation and sensitivity analysis of the key operating parameters. The first part of this paper focuses on a based-case BIG-FTs process with a maximum production of liquid transportation fuels and surplus electricity for a pioneer plant. This includes a preliminary conceptual process flowsheet, with some types of reaction, mass and energy conversion and separation units. In the second part, an economic assessment i.e., the capital investment and operating cost of the two alternative routes was estimated based on current technology availability. The cost-benefit of the synthetic liquid fuel production was calculated for a first plant and employed to allow comparison with biomass gasification for direct electricity production scenario. As the results, the obtained data can be used by investors/outsiders to close-up the second generation bio-fuel technology with trusting before deciding an investment project in this country.

2. Material and methodology

2.1. Conceptual design of the biomass-to-energy process

The commercial software ASPEN Plus® program version 7.2 under the academic license was used to model BIG-FTs process in the aspects of material and energy balances, design specifications and sensitivity analysis at steady state operation. The possible block flow diagram (BFD) devised for the biomass-to-energy pathways was created. The configuration was composed of five major unit operation models, including biomass handling and drying, biomass gasification, syngas cleaning and conditioning, FT synthesis and products separations, along with two utility supporting units which were Air Separation Unit (ASU) and electric power generation. Detailed process descriptions were presented in the following sections.

For this approach, some promising process schemes were studied based on subjective evaluation of economic, environmental, operating conditions and other criteria by some companies [8, 9]. Normally, the total number of five processing areas was referred for BIG-FTs processes. Firstly, A100 was a biomass feedstock processing area whereas biomass handling including biomass size reduction, screening, drying, and waste heat production was located. Secondly, when we connected about possible configurations of gasification-based biomass-to-energy unit, absolutely, the biomass gasification technologies can work as stand-alone applications or as part of integrated or modular systems combining pyrolysis, gasification and combustion processes [10].

For this work, A200 was considered for a gasification area, herewith an indirect gasification process such as a fluidized bed gasifier and a separate char combustor unit was referred as simple construction and operation, lowest capital and operating cost, and high internal heat circulate rate between the dual-bed. Afterward, the configurations of A300 were sketched as a combination of two sections [11]: syngas cleaning and syngas utilization. The first defines the syngas cleaning that can be removed some contaminates from the source via exiting conventional technology which the quantity and quality of this syngas was further set. Inside the cleaning zone, two cleaning methods (hot and cold) incorporated with physical and chemical pre-treatment were presented. At the beginning, the product syngas was fed into parallel activated carbon filters to disposal tars, and the cooled down by spraying water/solvent into a scrubber column.

The possible syngas utilization section indicates that the cleaned syngas can be used to convert the syngas into two pathways: synthesis to produce transportation fuels and combustion to generate electricity. Both of them have its advantages and disadvantages when coupled with a fluidized bed gasifier. On the one hand, four alternative options can theoretically produce a variety of transportation fuels such as hydrogen and liquid biofuels (methanol, dimethyl ether (DME) and FT synthesis). In the FT synthesis concept, within the system boundary of this study, A400 was a FT synthesis area where biofuel outputs were produced at an expected syngas volume. Additionally, syngas feedstock from gas holder was directly converted to a broad range of hydrocarbons, i.e. includes the light hydrocarbons methane (CH_4), ethene (C_2H_4) and ethane (C_2H_5), LPG (C3–C4, propane and butane), gasoline (C5–C12), diesel fuel (C13–C22), and light and waxes (C23–C33), which require further refining and upgrading as regards to the A500, before in order to be met commercial premium grade oil specifications. For this concept, syngas feedstock from gas holder was carried out, which leads to demonstrate case considered in this study.

On the other hand, compressed syngas in the same resource was fed in a specific generator set (A600) which due to energy conversion device. Two most promising plant configurations were consisting of a "power mode" with a gas engine and a "heat mode" with an externally-fired gas turbine [12]. The following present in the next section detailed analysis on the basis of the mass and energy balances developed for a plant feedstock capacity of 10 ton/day (i.e., about 3500 ton/yr) of the selected biomass fuel, which corresponds to a net electric power output of approximately 216 kWe by gas turbine. Meanwhile, the other two utility supporting units were also added. The first one was an electric power generation unit (A600) and the second one was an air separation unit (A700) for supplying oxygen (O_2) and nitrogen (N_2) for the gasifier.

For this work, a systematic design approach by Linnhoff [13] and Douglas [14] was considered along with some design alternatives already mentioned in order to construct a process flow diagram (PFD) of a BIG-FTs process, which descripted simulation of equipment found in each process area can be interpreted as detailed hereinbefore. After screening and drying units, biomass (stream 1) from a temporary storage was delivered to the first of two fluidized bed gasifier reactors (R-101), while air was distributed into the unit from below via a gas distributor. Gasification process occurred at an atmospheric pressure and temperature of 900-1200^{o}C. Solid material (some unreacted char and sand) came out with product syngas (stream 3) for separation in a cyclone (CL-101). The process was assumed approximately 60% conversion. The char and sand (stream 4) then passed to the second fluidized bed combustor (R-102) where the combustion took place at atmosphere pressure and temperature of 1500^{o}C. This process was achieved with 90% conversion resulting in an almost complete conversion of bio-materials. The effluent (Stream 5) was fed into the second cyclone separator (CL-102), the heat conducted by sand (stream 6) was returned to the first gasifier to provide the heat necessary for converting the biomass into syngas, while flue gas (stream 7) normally passed through a fly ash removal device as baghouse filter (BF-101), a wet scrubber (WS-102), and then expelled through the stack tower (ST-101). Stream 3 passed through a gas cooling heat exchanger (HX-101) which generated process steam. Afterwards, the cooled syngas was fed to a wet scrubber (WS-101) to remove some particulate solids such as dust, soot and fly ash in stream 8. Small amounts of particulate matter (stream 9) were sent to the first separator unit (S-101) to eliminate acid gas such as H_2S, HCl and NH_3 which can be harmful to FT catalyst. After passing through a cleaning unit, dry syngas capacity of 7x10^6 Lit/day was produced containing 10% of H_2, 12% of CO, 58% of N_2, 15% of CO_2, and 5% of CH_4 by volume. Raw syngas was compressed in order to be kept in a storage tank before processing to electricity and/or synthetic liquid fuels. For liquid fuel production, the cold gas (stream 11) was pre-heated (PH-101) to a temperature ~20 ^{o}C less than the FT reaction temperature. Next, Stream 12 and hydrogen added on for the process were fed into FT fixed bed reactor (FT-101). Gaseous stream (stream 13) and liquid hydrocarbons (stream 14) were the outputs of the FT unit.

Gaseous fraction was separated out as an off-gas (C1-C4) to be either recycle or burned (BUR-101), while liquid fraction comprised of synthetic fuels mostly C5+ hydrocarbon and water. Stream 14 was fed into the second separator column (S-102) to control hydrocarbon liquid drop out (stream 15) and the resulting stream (stream 16) was sent into a hydroprocessing unit. By using a distillation packed column (D-101), with hydrogen fed to hydrocrack the hydrocarbons, almost gasoline was obtained as top product (stream 17), jet fuel (stream 18), and diesel oil (stream 19). The simulation results were summarized hereinbelow. The overall productivity for 40% conversion of FT once through mode operation was to be 490 Lit/day x 0.75 density of kg synthetic fuel per Lit/10,000 kg dry biomass per day = 0.037 kg synthetic fuel per kg dry biomass. The off-gas flowrate of 144,000 Lit/day or 2.03 x 10^{-3} kg off-gas/sec can be multiplied by 5.4 MJ/$kg_{Off\text{-}gas}$ to calculate a required minimum 11 kJ/s or 11 kWe for surplus electrical production. Also, co-product as surplus electricity from the FT plant was sold at a price equal to \$1.5/kWh which was the same cost of generating electricity using the least-costly stand-alone biomass gasification system. For the electric rate per kWh, it will be discussed on the next section of this article.

The yield of biomass gasification for producing syngas can be estimated by converting syngas capacity from 7x10^6 Lit dry syngas per day to 0.0987 kg dry syngas per second at 30°C and atmospheric pressure. Yield (%) can be evaluated as 0.0987 x 3,600 x 24 kg dry syngas per day and divided by 10,000 kg dry biomass per day x 100, which equals to 85.27%. These processes gained its own efficiency as 0.037 x 100 = 3.7%. This value is quite far when compared with 13.4% of an overall yield by R. M. Swanson [15] for FT synthesis at low temperature scenario. At that case, 47.2 gal x 3.785 Lit per gal x 0.75 kg per Lit / 1,000 = 0.134 kg liquid fuel per kg dry biomass feedstock was presented. Additionally, in a typical demonstration BTL plant an average of 0.105 kg liquid fuel per kg dry biomass feedstock was proposed [16].

2.2. Economic analysis

After material and energy balances had been done, the cost estimation was performed subsequently. Costs for common equipment such as pumps, compressors, heaters and heat exchangers were calculated by the ASPEN Icarus Process Evaluator (IPE). The costs of core processing units in gasification and FT synthesis parts were separately estimated by our local information. They were calculated based on the existing pilot scale configurations and sizes fabricated in Thailand. The economy of scale was embedded in the following relationship, which exponential scaling was applied to adjust the purchased equipment costs using Eq (1):

$$Scale-up\ equipment\ cost = Base\ equipment\ cost\ \left(\frac{Scale-up\ capacity}{Base\ capacity}\right)^n \quad (1)$$

The characteristic scaling exponent, n, was typically in the range of 0.48 to 0.87 for process equipment and from 0.38 to 0.90 for plants [17]. The sizing parameters were based on a characteristic of the equipment related to production capacity. However, Eq (1) was assumed that all other process parameters (pressure, temperature, etc.) remain constant relative to the base case. Scaling exponents were determined from several sources [18-22]. When cost data were not available in 2013 dollars, costs were adjusted with Chemical Engineering's (CE) Plant Cost Index, December 2011 [23] to take into account changing economic conditions (inflation). This can be achieved by using the following Eq (2):

$$Corrected\ equipment\ cost = Base\ equipment\ cost\ \left(\frac{2013\ cost\ index\ value}{Base\ year\ cost\ index\ value}\right) \quad (2)$$

In order to obtain the f.o.b. (free-on-broad) purchase cost, C_P, evaluation with preference was given in the order shown here before multiplying with each bare module factor, F_{BM}. This one was factored in direct field material and labor, and indirect expenses such as freight, insurance, taxes, overhead, and engineering. In order to achieve the bare module cost (C_{BM}) or installed cost of each equipment type, the C_{BM} was calculated as $C_{BM} = C_P \times F_{BM}$ as listed in Table 1. After that C_{BM} was summarized to provide the total bare module cost, C_{TBM} which refers to the summation of bare module costs for all items of BTL process equipment. Other investment costs included site preparation, C_{site} (5% of C_{TBM}), service facilities, C_{serv} (2% of C_{TBM}), allocated costs to purchase the utility plants, C_{alloc} (14% of C_{TBM}), and engineering and supervision, C_{eng} (10% of C_{TBM}), based on Seider [17]. These were added to C_{TBM} to give the direct permanent investment, C_{DPI}. Project contingencies and a contractor fee were added as 20% of C_{DPI}, and the total depreciable capital, C_{TDC}, also referred to as fixed capital investment (FCI), was obtained. For initial estimation of the operating costs, a mean value of $100/ton biomass (woodchip) feedstock was informed during the pulp and paper plant visit. The value included delivery cost which cumulative distance must not exceed 100 km from a BTL plant. Catalyst replacement costs were estimated at 1% of FCI. The labor cost was based on the operational areas. In this case, 20 operators were prepared, and an average cost of $12,000/year per operators was used. Table 2 concluded the calculation of the total production cost and the unit production cost. The total production cost for a BTL plant 161,700 Lit/year was approximately M$9 while the unit production cost was around $12.76/Lit (€28.2/L). This is higher than the current price of fossil fuel in Asia markets which is around €0.96/L (≈$4.83/gal). In another route, the specific cost of gasification processes for stand-alone electricity production was also summarized except for costs of A400 and A500. The cost was found promising starting from the capacities of 217 kWe. This value can be determined by multiplying with the syngas low calorific value equals to 4.4 MJ/kg_{syngas} [24]. Consequently, the electrical output can be calculated as $(9.87 \times 10^{-2} \times 4.4) =$ 434 kWe. However, several theoretical studies on the opportunity to generate electricity from biomass have been conducted [25], but with a low of conversion in electrical energy loss that, in many cases, a net electrical existing was only receive 50% of initial input. By calculating electricity energy output per dry syngas fuel, 217/(0.0987x3600) = 0.61 kW per kg/hr of dry syngas fuel was the final result. This value showed small difference from the value of 0.66 kW per kg/hr of dry syngas fuel presented by A. Molino et al., 2013 [26]. The annual production cost of electricity was estimated as M$1.3, while the unit production cost can be summarized as $0.71/kWh (€0.54/kWh) by applying the formula price from Larson [27] and Fischer and Pigneri [28]. However, summary data of electrical production cost estimation was not detailed in this paper. The profitability of this process can be determined from the operating costs and profitability analysis.

Product value (PV), Return on investment (ROI), Payback period (PB), and the Discounted cash flow rate of return (DCFR) are the key financial indicators for identifying economic situation. Key assumptions included 60% plant capacity factor has been set according to the current national fiscal imposition in Thailand. Our base case financing assumed a real rate of return on equity (ROE) of 14%/yr, giving a real weighted after-tax cost of capital (discount rate) of 7.8%/yr and a levelized annual capital charge rate of 15%. Additionally, a plant availability of 8,400 hr (350 day/yr) was assumed as the minimum target [14]. Next, structure of two model price for performing the economic evaluation calculations was provided in a separate EXCEL spreadsheet, and then was summarized in Table 3. ROI, PB and PV of both the BIG-FTs and the BIG-GT process were calculated by applying a formula from some literatures [27-29] as shown below.

Table 1. Summary of installed equipment costs for BIG-FTs plant capacity: 161,700 Lit/year

Cost items	Installed cost, C_{BM} ($)	%
➲ Operational areas		
A100: Biomass handling	331,195	3%
A200: Gasification system	1,167,300	12%
A300: Syngas cleaning	732,021	7%
A400: FT synthesis	3,166,412	32%
A500: Hydroprocessing	350,000	4%
A600: Electric power unit	167,000	2%
A700: Air separation unit	334,577	3%
Total installed cost or bare module cost (C_{TBM})	6,248,505	64%
➲ Indirect costs (IC)		
- Site preparation (C_{site})	312,425	
- Service facilities (C_{serv})	124,970	
- Allocated costs (C_{alloc})	874,791	
- Engineering and supervision (C_{eng})	624,851	
Total Indirect costs (C_{TIC})	1,937,037	20%
Direct permanent cost, C_{DPI}	8,185,542	
Contingency & contractor's fee	818,554	16%
Fixed capital investment (FCI)	9,004,096	100%

Table 2. Summary of operating cost calculation for BIG-FTs plant capacity: 161,700 Lit/year

Cost items	Calculation	(US$)
➲ Variable cost items		
1. Material cost (C_{RM})	3,500 ton/yr	330,000
2. Catalyst and chemicals	1% of FCI	90,041
3. Utilities cost (C_{UT})	From mass and energy balance	162,074
4. Hydrogen cost	From mass and energy balance	80,082
Total variable costs	(1) + (2) + … + (4)	762,197
➲ Fixed cost items		
5. Maintenance	5% of FCI	450,205
6. Operating labor (C_{OL})	20 persons	240,000
7. Overheads	5% of FCI	450,205
Total fixed costs	(4) + (5) + … + (10)	1,140,410
Direct production costs (C_{DPC})	Total Variable + Total Fixed costs	1,902,606
8. General overheads + R&D	5% of C_{DPC}	538,455
9. Depreciation (d = FCI/n)[1]	20 year	450,204
Annual production costs	(1) + (2) + … + (9)	2,714,806

1) Annual depreciation based on the straight-line method

3. Results and discussion (Profitability indicators)

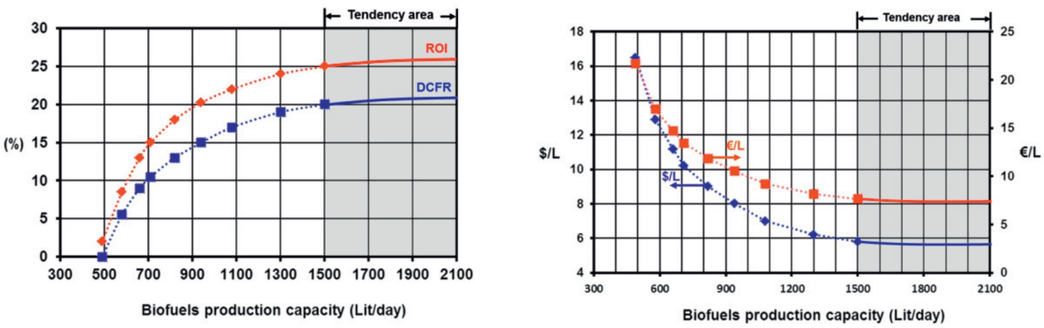
From the key results as shown in Table 3, the biofuel production scenario namely BIG-FTs has higher in the total capital costs due to additional equipment required for FT synthesis unit (A400) and hydroprocessing unit (A500) compared to the electricity production scenario namely BIG-GT. Moreover, annual operating costs were higher for the BIG-FTs which can be explained by an increase of some utilities, chemicals, and catalysis materials. The breakdown structural price in terms of US$ dollar per unit of both scenarios was presented. Obviously, the production unit costs of both 1st plants were $16.79/L and $0.71/kWh for the BIG-FTs and BIG-GT, respectively. These values depend on the complexity of process elements due to the economical scaling effect and productivity. To improved PV for the BIG-FTs, an increase of FT conversion in FT unit can be one option that could impact on economics of this scenario. This was done on the next sensitivity analysis in this context. However, the higher ROI in the BIG-GT was due to increase in the product revenue from higher electricity yield, while the ROI of the BIG-FTs was given the risk to an unacceptable level. The levelized unit cost of BIG-FTs was considered high by world standard which was proposed by Swanson [15] to be approximately $3.0 per liter of gasoline equivalent. The production cost in this scale was around $16.79/L biofuels, which was not economically feasible and difficult to determine profitability for competitive with fossil fuels. However, this price might be reduced further to $5.84/L biofuels when the productivity was raised up to 1,500 Lit/day. Tracking productivity may require some improvements which can be rising per pass carbon monoxide conversion up to 80% in the FT reactor by arranging recycle streams. This depends on the size and complexity of the FT processes, however a maximum product of biofuel is usually limited by catalysis conditions. Nevertheless, after some improvements have been done, the structural price may appear more cost-competitive.

Table 3. Summary of key results for useful life time of 20 yrs

Cost items	BIG-FTs	BIG-GT
A. Product capacity (Unit/yr)	161,700 L	1.8×10^6 kWh
B. 1st Plant fixed capital cost ($)	9,004,096	3,786,681
C. 1st Plant total capital cost ($)	11,255,120	4,733,351
D. Annual operating cost ($/yr)	2,714,806	1,288,812
E. Annual product income ($/yr)	2,893,659	2,721,600
Key financial indicators		
ROI (%) = (E-D)/C x 100%	2%	30%
PB (yr) = B/(E-D)	50.34 yr	2.64 yr
PV ($/unit) = D/A	$16.79/L	$0.71/kWh

For sensitivity analysis of BIG-FTs, two profitability indicators can be presented as in Fig. 1a. Two reports written by B. Bao [29] and A.A. Apostolakou [30] suggested that a typical industrial investment should be at a minimum of 10% ROI and DCFR requirement. The figure indicated that the capacities below approximately 700 Lit/day or 231,000 Lit/yr should be avoided since the plant operation cannot be profitable due to the ROI and DCFR lower than 10%. In Fig. 1b, the two unit production costs as a function of BIG-FTs plant capacity were optimized simultaneously. For production capacity of 490 Lit/day, the unit cost was estimated as of $16.79/L (€21.72/L), and it decreased sharply as the production capacity increased up to 1500 Lit/day ($5.84/L or €7.63/L). This price may be significantly reduced by technology learning and then represent a low-cost option for renewable energy. For the capacities above 1500 Lit/day (tendency area), these results were not valid, and were presented only to show the tendency to over specify when biofuels production levels can be climbed.

For stand-alone electricity production of BIG-GT plant, the capital cost in this work was approximately $0.71/kWh which was slightly higher than the current price of the local electricity. Absolutely, the cost of electricity from dedicated solid biomass plants depends on technology, feedstock quality and cost, regional location, and size of the plant. Small size means higher investment cost per kW and lower electrical efficiency. Previous report data by IEA Energy Technology Essentials 2007 [21] illustrated that the generation costs from small and medium biomass gasification plants (10-30 MWe), even at higher efficiencies, were expected to be some $0.11-$0.13/kWh, less than seven times the cost of this work.



(a) (b)

Fig. 1. (a) ROI and DCFR as a function of biofuels production capacity (Lit/day)
(b) Two unit production costs of US ($) and Euro (€) as a function of biofuels production capacity (Lit/day)

Investment in demonstration scale could yield additional income from directly sale of electricity. BIG-GT definitely showed more profitable than BIG-FTs. Economic analysis showed that the BIG-GT could meet the PB in 2.64 years, and ROI is 30%. In addition, the leading advantage of the BIG-GT, with enforcing renewable sources would be made to ensure that this scenario avoids consumption of fossil fuel resources. For example, almost of 50% of electricity production in Thailand is provided from the combustion of natural gas or other forms of fossil fuels. These sources are imported from Myanmar and other foreign countries. This work is an illustration for producing inexpensive and renewable energy from domestic sources to help reducing dependency upon foreign sources of fossil fuels.

4. Conclusion and Outlook

In this work, techno-economic of biofuel production plant that utilized syngas from a gasification process to feed in an FT unit was investigated using the data of an existing gasification plant installed in Thailand. Five and three areas were modeled for the BIG-FTs and the BIG-GT plant respectively. Estimations of the unit production cost and fixed capital investment for a wide range of both production capacities were calculated. In detail, BIG-FTs plant for producing biofuels resulted in higher plant costs (around 60%) than BIG-GT plant. The low conversion incurred by FT unit affected the unit production price and resulted in a lower biofuels product value (PV). However, with a 30% uncertainty on the capital investment and production costs, there were some suggestions for BIG-FTs improvement that can be done to push this scenario more economic in the near future.

The sensitivity analysis showed that both ROI and DCFR of the BIG-FTs plant capacities less that 10% should be avoided as the plant operation cannot be profitable. The BIG-GT plant always retained good competitive performance for investment. However, having the BIG-FTs plants in Thailand has facilitated economic and social development in the community. They can be beneficial when the country confronts a very high price of fossil fuels in the future. The use of existing gasification infrastructure located in many provinces can be our choices for the BIG-FTs plants.

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